

When Talent is Not Enough: Why Technologically Talented Women are Not Studying Technology

The position of technology education in Finland is quite different from that in most other European countries, even for Finland's Nordic neighbors. Technology education is incorporated within the scopes of other subjects, such as physics, chemistry, biology, home economics, and craft education. Craft education is, in practice, further divided into technical work and textile work. Although the national curriculum stated as early as 1970 that both technical and textile crafts are compulsory for both boys and girls, traditionally, boys select technical crafts and girls choose textile classes. As technological contents are mostly taught in the technical craft lessons, this division has a negative effect when students select subjects such as physics in upper secondary school and when they make considerations to study in technical universities and science departments in universities. Gender-based segregation and falling recruitment for scientific and technological studies are common phenomena in all the Nordic countries (Sjøberg, 2002). However, paradoxically the inequity is particularly noticeable in Finland where gender equality has been a prime educational goal for decades.

This article builds on two earlier studies. The first one defined and assessed technological competence among adolescents (Autio & Hansen, 2002). The second, traced three students who had achieved the best results in a measurement of technological competence given 15 years ago (Autio, 2011). This study showed that, in terms of technological competence, it is possible to predict students' potential for career success in the technical professions. The aim of this study was to examine how the three highest scoring females have progressed. Are they working in technology today, or did they find other professions? In addition, the researcher tried to determine the elements accounting for the participants' motivated behavioral choices in the area of technology. Finally, in the discussion section, the researcher will highlight some differences within these elements between males and females. The main research questions were as follows:

1. Did technologically talented females choose technological careers?
2. What were the main elements in the test participants' motivated behavioral choices in the area of technology?

The research data was analyzed using content analysis. The analysis was carried out by assessing which of the essential elements in the participants' lives contributed to their motivated behavioral choices in the area of technology. These findings were later classified and finally reported in the conclusions. The

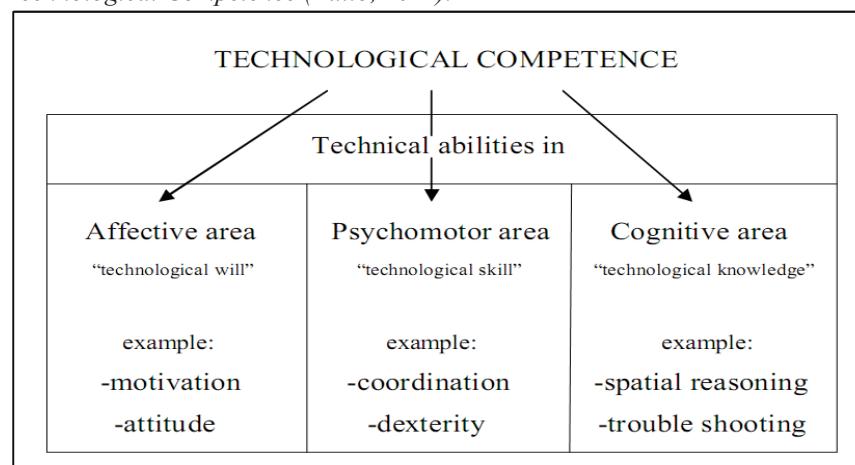
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results from each participant interview are shown in a figure based on Eccles' (2009) Expectancy Value Model of Motivated Behavioral Choice. The model indicates test subjects' motivated behavioral choices in the area of technology during their lives. These figures, which are based on the expectancy value theory, will be explained in more detail later.

Theoretical Background

Despite the fact that skilled behavior underlies nearly every human activity, the profession's understanding of the factors that contribute to the attainment of expertise in technology education is far from complete. However, some attempts to define technological competence have been made. For example, Autio and Hansen (2002) defined technological competence as an interrelationship between technical abilities in psychomotor, cognitive, and affective areas. Based on Dyrenfurth's (1990) and Layton's (1994) work, they identified three components that correspond with what the authors considered the dimensions of technological competence. In the present study, technological competence was defined as an aggregate of the three abovementioned measurements: knowledge, skill, and emotional engagement. A simplified model of technological competence is described in Figure 1.

Figure 1
Technological Competence (Autio, 2011).



During the interviews, typical elements affecting motivated behavioral choices in the area of technology were identified. These were classified according to Eccles' (2009) Expectancy Value Model of Motivated Behavioral Choice. Expectancy value theory has been one of the most important theories on the nature of achievement motivation, beginning with Atkinson's (1957) seminal

work and more recently developed by Eccles, Adler, Futterman, Goff, Kaczala, Meece, and Midgley (1983); Wigfield and Eccles (1992) and Eccles (2008). Atkinson's (1957) original expectancy value model defined expectancies as individuals' anticipations that their performance will be followed by either success or failure, and defined value as the relative attractiveness of succeeding or failing in a task. Later the model was expanded to discuss how an individual's expectancies for success, subjective task values, and other achievement beliefs mediate their motivation and achievement in educational settings. The most recent model consists of several factors or themes, including a distal cultural milieu that encompasses the cultural stereotypes and behaviors of key socializers. In addition, an individual's perceptions of emerging self-knowledge generates his or her future goals and shape self-confidence. Furthermore, individual characteristics and experiences are important in the interpretation of previous experiences. These elements later generate the expectation of success and subjective task values. Finally, based on life experiences and complicated decisions between all the elements in the model, individuals make motivated behavioral choices.

It seems that the process of making motivated behavioral choices in the area of technology is more complicated for technologically talented females than for males. This is supported by the statement that women appeared to place high attainment value on several goals and activities; in contrast, the men appeared more likely to focus on one main goal (Eccles, 2009). In addition, women are more likely to desire a job that directly helps other people and involves working collaboratively with other people. This seems to be one reason why mathematically talented women go into the biological and medical sciences instead of physical sciences and engineering (Vida & Eccles, 2003). Moreover, only a few girls are willing to challenge stereotypes about nontraditional careers for women (Silverman & Pritchard, 1996; Mammes, 2004), and even technologically talented females tend to underestimate their own capabilities (Wender, 2004).

Study Method

Case study research excels at bringing people to an understanding of a complex issue or object and can extend their experience or add strength to what is already known through previous research. Case studies emphasize detailed contextual analysis of a limited number of events or conditions and their relationships (Stake, 1995). It is true that a case study is a detailed examination of a single example, but it is not true that a case study cannot provide reliable information about the broader class (Flyvbjerg, 2006).

The research was carried out as a qualitative case study (Merriam, 1988), and the data was collected from individual theme interviews. The analysis was carried out by assessing which of the essential elements in the Expectancy Value Model contributed to motivated behavioral choices in the area of technology

during the test subjects' lives. Next, the data was analyzed using content analysis methodology (Anttila, 1996; Baker, 1994). Prior to the interviews, the researcher conducted a short e-mail discussion with each test participant about the concept of technological competence and about the Expectancy Value Model of Motivated Behavioral Choice. Each participant understood that technological competence was defined in the study as an aggregate of three areas: knowledge, skill, and emotional engagement. In addition, they understood that the Expectancy Value Model was just a starting point, and as the interview was based on self-reports, there was no right or wrong answers.

Study Participants

The study group consisted of three women. One of them was born in 1980 and two in 1982, and when they were tested for technological competence 19 years ago as students, they achieved the best results in the girls' test group. In Finnish technology education, boys traditionally select technical crafts and girls choose textile classes. However, the curriculum of technology education in 1994 specified that technical craft and textile craft should be combined into one subject, taught to both boys and girls over their entire comprehensive school lives. This curriculum was tested in 1993, and test participants in this study were given a new curriculum that combined technical and textile craft in grades five to seven. Although there was still much to improve and the curriculum was not optimal for young girls, we can suppose that all the test participants had experiences in the field of technology and were at least aware of the availability of this option. In addition, their schools were clearly aware of gender roles and cultural stereotypes.

Test participants' technological competence (TC) was defined as an aggregate of three measurements: technological will (TW), technological skill (TS) and technological knowledge (TK). The formula of technological competence ($TC = TW \times TS/2 \times TK/5$) was obtained so that each element had equal emphasis, but if any of the elements were close to zero, the technological competence drew close to zero as well. Therefore, the test subjects were selected according to their overall accomplishment in all three areas. In the original test group of 267 participants (161 boys and 106 girls) 19 years ago, a number of girls performed better in certain areas (e.g. technological knowledge) but did not succeed as well in the other areas. Technological will was measured by a questionnaire with fourteen Likert-scale (1–5) statements (final score: average reply to statements). The test of technological skill was called X-boxes and the aim was to construct as many items as possible in five minutes (final score: the amount of constructed items). The test of technological knowledge consisted of 28 questions related to physical laws in simple machines (final score: the amount of right answers). More information on the research group, the test instruments, and other data from the original study is available in Autio (1997) and Autio and Hansen (2002). The results of the test subjects and the

average test scores from the previous study held in years 1993–1995 are presented in Table 1.

Table 1
The Results of the Test Subjects and the Average Test Scores

	Technological Will (TW)	Technological Skill (TS)	Technological Knowledge (TK)	Technological Competence (TC) ^a
Subject 1	3.07	10.25	20	62.94
Subject 2	3.70	6.50	22	52.91
Subject 3	2.86	11.25	23	74.00
Average of 3 best female	3.21	9.33	21,67	63,28
Average of 3 best overall	4.19	9.06	26.33	99.95
Average of all females (n = 106)	2.81	6.12	18.20	31.30
Average of all (n = 267)	3.37	6.35	20.34	43.53

^a Technological competence: $TC = TW \times TS/2 \times TK/5$

According to the test results 19 years ago, the selected test subjects were definitely technologically talented but not as talented as the three highest scoring participants overall. The average of their technological competence was 63.28. It was higher than the average of all test participants (43.53); however, it was much lower than the three best scores overall (99.95). The main difference seemed to be in technological will and technological knowledge, whereas the three best females performed better in the measurement of technological skill.

The test participants were difficult to trace, but with the help of their old teachers, old schoolmates, and the Internet, they were found after two months of investigation. Although 267 students were tested 19 years ago, coincidentally, two of the test participants had graduated from the same school in the Helsinki

metropolitan area. The third participant was also a resident of Helsinki, but graduated from a smaller upper secondary school. The researcher had no previous knowledge of the test subjects' current employment status. Fortunately, the background of each test subject was somewhat different, and the researcher could find support to previous statements. For example, women value competence in several activities simultaneously (Eccles, 2009), mathematically talented women go into the biological and medical sciences instead of physical sciences and engineering (Vida & Eccles, 2003), and even technologically talented females tend to underestimate their own capabilities (Wender, 2004).

Two of the participants had studied at a university of technology. The first was quite sure of her decision to choose a career in technology after secondary school, but the second had a lower self-concept related to technology and started her studies in the university of technology a couple of years later. The third test subject was equally talented in technical matters, but mainly due to a lack of self-confidence and encouragement from her main socializers, she began to study economics in vocational high school instead of continuing in a more technological direction. The test participants were named according to their characteristics, as follows:

- Subject 1: From machine technology to an architect
- Subject 2: Academic single mother
- Subject 3: Technological talent without self-confidence

Results

Each test participant's educational path related to technology is presented in the next section. The descriptions of the educational paths were based on the Expectancy Value Model of Motivated Behavioral Choice. The model was first introduced to the test subjects by e-mail and then discussed within the theme interviews in more detail. The elements of the motivated behavioral choices of each test subject are described more precisely in Figures 2–4. As the results were based on self-reports, no absolute value was given to the strength of each element.

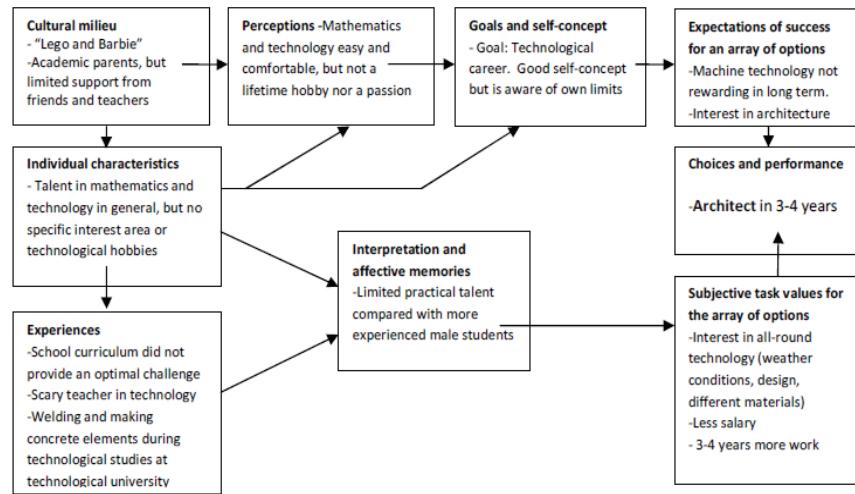
Subject 1: From Machine Technology to an Architect

Subject 1 was born in 1982 and spent her school years in the Helsinki area. She lived with her parents and a little sister. Her father had earned a Master of Science in Technology (machine technology), and her mother was a Master of Science in Economics and Business Administration. Her little sister was currently studying in Italy (bioinformation technology). Subject 1 finished school in 2002 with good grades (the average of all school subjects over 9.0 / 10.00). After finishing upper secondary school, she started to study machine technology at a university of technology. However, after five years she changed her major to architecture. Currently, she is working in an architect office and still has 3–4 years of study before completing her degree.

Subject 1 had become familiar with technology in early childhood using Lego, but she played with Barbie as well. Subject 1 responded positively to technology education: early in comprehensive school she was already interested in how things work in general, but making technology-related products was not especially interesting. The teacher was capable, although the test subject thought that he was somewhat frightening for a small girl. Furthermore, she had no friends with the same interest area to join her in the technology education lessons. Her father was a good role model, but she did not get much support for her technological talent as her father was not at home very often because of his work. In any case, the support from her main socializers was limited, and in upper secondary school she recognized her technological talent mainly because she was good at mathematics, not because of her accomplishments in technology.

Yet she received the best encouragement from being able to understand how things work in everyday life. Her self-confidence in technology was high, and she did not need much support, as she felt comfortable in the technological world. During her later studies in machine technology, she received more experience in a real life technological environment. She became acquainted with welding and making concrete elements. She felt comfortable, but noticed that her skills were limited when compared with other students who had much more experience in the technological world from their hobbies. In any case, she thought that her competence in technology was growing, but she had no passion for any special phenomena in technology. Furthermore, she had no technologically related hobbies to develop her competence further. In the long term, studying machine technology seemed to be meaningless to her future. Because of this, she decided to change her major and started studying to be an architect. As she was a woman of diverse talent, she felt that this area was much more rewarding. She could fulfill her technological interest with topics related to technology: design, different materials, weather conditions, and sociological elements. As she had finally found a technological area that suited her talent, she was willing to accept three to four more years of studies and an even lower salary. The elements accounting for Subject 1's motivated behavioral choices are described in Figure 2 (next page).

Figure 2
The Elements behind Subject 1's Motivated Behavioral Choices



Subject 2: Academic Single Mother

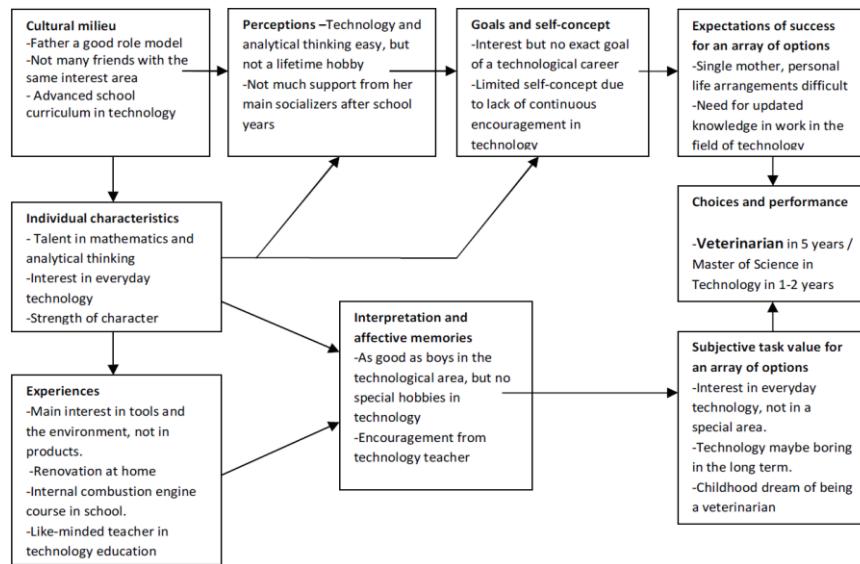
Subject 2 was born in 1982, and she spent all her school years in university training school in the Helsinki area. She lived with her parents and sister. The family was a typical Finnish family with no academic degrees. Her father was a janitor, and her mother was a homemaker, who occasionally worked in a supermarket.

Subject 2 graduated from university training school in 2001. The school was one of the highest ranked upper secondary schools in Finland. She was good at several school subjects and graduated with good grades (the average of all school subjects was about 9.3 / 10.00). After finishing upper secondary school, she started to study computer science in 2002 in vocational high school. However, as the studies were not as practical as she expected, she quickly realized that this was not what she wanted to do for the rest of her working life. In 2003 she transferred to an environmental technology program in a smaller town close to the Helsinki area in another vocational high school. She felt comfortable in her studies and recognized her technological talent, and she felt she had gained enough self-confidence to take part in the qualification exam of the technological university in Helsinki. In 2004, she began to study material technology in the technological university. Currently as a single mother she has had some breaks in her studies, but she thinks she can graduate as a Master of Science in Technology in one or two years. However, she still wonders whether her life as a single mother would be easier if she worked as a veterinarian, which was her childhood dream.

Since her early childhood, Subject 2 has been involved in technology-related activities, as her father was always doing renovations or working with cars. Fortunately, she was her father's favorite girl, and she was able to accompany him in all the work he was doing as a janitor. Subject 2 also had the opportunity to take some extra technology education lessons while studying in upper secondary school; she especially enjoyed the internal combustion engine course. The teacher was encouraging and like-minded, and her self-confidence grew when she could show boys her remarkable skills and knowledge in the technological area. In addition, she always felt comfortable doing the analytical thinking required in the technological area. Nonetheless, she has never had any specific aims or hobbies regarding technology. In order to develop her technological competence further, she thinks that she still needs continuous encouragement, as her self-confidence in real life is still limited.

Currently, she is in the middle of making hard decisions. As a single mother, her life could be much simpler if she worked as a veterinarian. She thinks that she could organize her daily routines much more easily if she had a private practice. On the other hand, she could finish her studies in material technology and graduate as a Master of Science in Technology in 1–2 years. Although she thinks that her ability is well suited to her current study area, she knows that in a technological area a diploma is not enough—updated knowledge is always required. In working as a veterinarian, not as much continuing education is needed. The elements accounting for Subject 2's motivated behavioral choices are described in Figure 3 (next page).

Figure 3
The Elements behind Subject 2's Motivated Behavioral Choices



Subject 3: Technological Talent without Self-Confidence

Subject 3 was born in 1980 and spent her school years in the Helsinki area. Her primary education was in a smaller school, but at the secondary level she enrolled in a university training school. In upper secondary school, she studied in a school that specialized in natural sciences. Her father worked for the social services department of the city of Helsinki, and her mother had her own office, which allowed her to freelance as an art director. In addition, her family consisted of an elder sister and a younger brother who was a talented electrician.

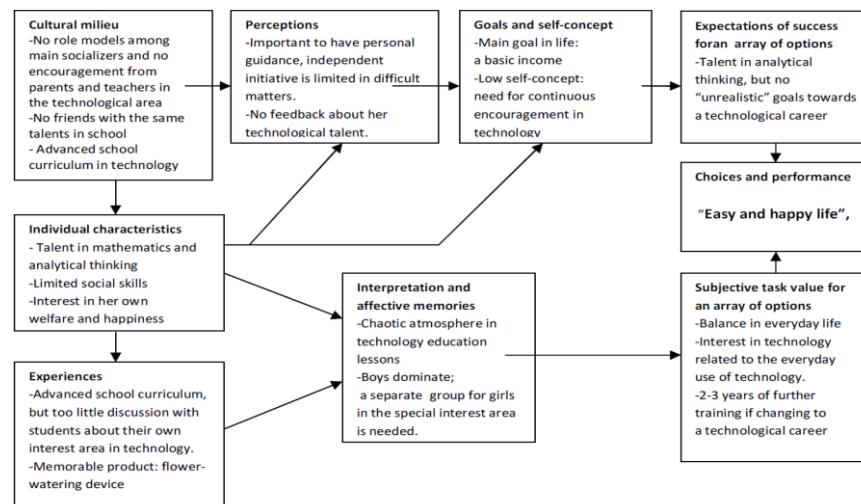
Subject 3 finished school in 1999 with good grades. In her opinion, she was good at all subjects, but felt especially comfortable in mathematics. After finishing upper secondary school, she started to study business economy in vocational high school, but she felt that personnel management was not what she wanted for her working life. Soon after she changed her plans, and in 2004, she graduated with a Bachelor of Business Administration degree. Since then, she has worked in several posts as an office assistant and as a contract coordinator. She feels that there is enough challenge in her working life.

Subject 3 had the opportunity to take technology education classes in secondary school, and she thinks that she could have been successful in that area. However, she had no friends with the same interest and no encouragement from teachers, parents, and other main socializers. The main problem for her was that her self-confidence and social skills were limited, and she did not

consider technology education studies further, as boys were too domineering in that area. In any case, she finished a few good projects, for example, a flower-watering device, but she wanted more discussion about technological phenomena, not just the product. Sometimes the lessons were chaotic, with loud noise from the machines and from the restlessness of the whole working group. She thinks that special technology education lessons just for girls would not have been as difficult.

Although she had opportunities and enough talent to develop her technological competence further, without any support and with limited self-confidence, she did not even realize that she was talented in the technological area. Thus, considering a technological career was never an option. In mathematics, for example, the feedback that she received was much more positive, and she knew her ability from the results of exams. However, she was not stereotyped as a nerd or as a person who did not matter, but she was not willing to challenge stereotypes about nontraditional careers for women. Nevertheless, her mathematical talent is valuable in her current duties, and she feels comfortable whenever analytical thinking is required. Currently, growing in her work in her current post is her most important priority, and she has no other specific goals in her life. Although she has always thought that her analytical skills would have been valuable in the technological area as well, an easy life with a basic income is enough for her. The elements accounting for Subject 3's motivated behavioral choices are described in Figure 4.

Figure 4
The Elements behind Subject 3's Motivated Behavioral Choices



Conclusions

In this study, the three female students who had the best overall results in a test measuring their technical abilities 19 years ago were followed. The researcher had no previous knowledge of how these three test participants were currently employed. This study tried to determine: Did the technologically talented females choose technological careers? The researcher found that two out of three test participants were currently studying at technological university. The third test subject was equally talented in technical matters, but mainly due to lack of self-confidence and encouragement from her main socializers, she did not choose a technological career. The study supports the finding from Autio (2011) that it is possible to predict student potential for career success in technical professions with the instrument used in the measurement. It is not guaranteed, but we can assume that it is not just coincidence that two out of three test participants were currently considering a technological career.

The next study question was: What were the main elements in the test participants' motivated behavioral choices in the area of technology? According to Eccles (2007), the kinds of educational and vocational decisions that might underlie gender differences in participation in physical science and engineering would be most directly influenced by individuals' expectations for success and the importance or value that individuals attach to the various options that they see as available. In this study, many elements had an influence on the motivated behavioral choices in the area of technology long before the test participants considered their expectations for success or gave value to the options that they saw as available. Consistent with the most recent simplified version of the Expectancy Value Model of Motivated Behavioral Choices (Eccles, 2009), cultural milieu, individual characteristics, and previous experiences seemed to be the main elements in the beginning of the process in making motivated behavioral choices. If these elements are not in balance, the individuals do not actively, or consciously, consider the full range of objectively available options in making their selections. Many options are never considered because the individual is unaware of their existence or the individuals think these options are not realistically available to them (Eccles, 2008).

In the measurement of technical abilities 19 years ago, the test participants were found to have technological talent, and it was easy to conclude that the selected test subjects' individual characteristics were suitable for a technological career. According to Byman (2002), students usually prefer and choose subjects and tasks in which they are proficient and can show their competence. In addition, Eccles (2009) predicts that people select those activities for which they feel most efficacious (or for which they have the highest expectations of success). Furthermore, Betz and Hackett (1986) demonstrated a link between the ratings of personal efficacy in various academic subjects and career choice. In addition, all three test participants had an opportunity to take technology education lessons in a school with an advanced technology education

curriculum. Although the curriculum was not optimal for introducing technology to young girls, all the test participants had experiences in the field of technology and were at least aware of the availability of this option. What is more, the schools were clearly aware of gender roles and cultural stereotypes. During the interviews, none of the test participants mentioned that these elements were negative features.

Unfortunately, the support from their main socializers in the field of technology was not mentioned as positive during the interviews, and all test participants reported limited support from parents, teachers, and friends. Adolescents are especially concerned with peer relationships and may be in special need of close adult relationships outside of the home (Eccles, 2008). Reeve, Bolt, and Cai (1999) have shown that teachers who support students' autonomy in decision-making create more intrinsic motivation than those who intend to control their students. Support of autonomy is evident when an authority figure respects and takes the subordinate's perspective, promotes choices, and encourages decision-making (Ratelle, Larose, Guay, & Senecal, 2005). Furthermore, parents, teachers, and peers tell people what they are good at or not good at with very little information on which to base such conclusions (Eccles, 2009).

In summary, Subject 1 had talent and enough experience to be aware of the options available in the field of technology. Although the support from her main socializers was limited, her self-confidence in technology was high, and, actually, she did not need much support, as she felt comfortable in the technological world. As she was a woman of diverse talent, she probably can fulfill her technological interest through different topics related to technology: design, different materials, weather conditions, and sociological elements. It seems that she is willing to accept three to four more years of studies to be an architect. Her choice corroborates with the idea that women seem more likely than men to be involved in, and to value, competence in several activities simultaneously (Eccles, 2009; Baruch, Barnett & Rivers, 1983).

Subject 2 was equally talented and had plenty of experiences in the field of technology, but to develop her technological competence further, she thinks that she still needs continuous encouragement, as her self-confidence in real life is still limited. Currently, she is in the middle of making hard decisions. As a single mother, her life could be simpler if she worked as a veterinarian. Her choice is consistent with the statement that mathematically talented women go into the biological and medical sciences instead of physical sciences and engineering (Vida & Eccles, 2003).

Subject 3 was equally talented in technical matters and had enough experience to be aware of the options available in the field of technology, but mainly due to a lack of self-confidence and encouragement of the main socializers, she did not continue in a more technological direction. Being unaware of her technological talent, she did not even consider a technological

career, as she thought that those options were not realistically available to her. This case was also supported by the statement that even talented females tend to underestimate their own capabilities (Wender, 2004).

Discussion

The study had obvious limitations. The research group was small, and the participants could have misremembered details from their pasts, just as the researcher could have misunderstood some of the details during the interviews. In addition, making motivated behavioral choices in practice is a much more complicated process than we can describe with a single figure. In any case, this study corroborates with the Expectancy Value Model of Motivated Behavioral Choices (Eccles, 2009), in which cultural milieu, individual characteristics, and previous experiences seemed to be the main elements in the beginning of the process of making motivated behavioral choices. If any of these basic elements are not present, the individuals' self-concept in technology is limited, and they do not consider the full range of objectively available options in the field of technology. In addition, many options are not even considered because the individuals are unaware of their existence or think that these options are not realistically available to them (Eccles, 2008).

Although we must be cautious about the conclusions, there is some evidence to assume that the process of making motivated behavioral choices in the area of technology is much more complicated for technologically talented females than for males. In previous research (Autio, 2011), male test participants were already working in technological professions, while technologically talented female test participants in this study were still considering other options. It seems that male test participants found their own expertise area much easier and finished their studies quickly with a relatively small amount of other options. This conclusion is supported by Eccles (2009) and Vida & Eccles (2003). In addition, only a few girls are willing to challenge stereotypes about nontraditional careers for women (Silverman & Pritchard, 1996; Mammes, 2004).

According to Autio (2011), the most important elements that affected male participants' technological competence were curiosity, interest, the student's own needs, and intellectual challenge. These elements were not mentioned during the interviews of three highest scoring females, and it was clearly seen that their interest was restricted to everyday technology instead of specialized areas. Technology-related hobbies (e.g. Lego, computers, cars, and electronics) were definitely another element distinguishing between males and females.

Furthermore, in the previous study (Autio, 2011), an emotionally supportive and encouraging teacher-student relationship was mentioned by all the male students as one of the main elements in developing their technological competence. This is consistent with Eccles (2007), who states that males receive more support for developing a strong interest in physical science and

engineering from their parents, teachers, and peers than females. In addition, it is reported that males receive more teacher attention than females (AAUW report, 1992; Silverman & Pritchard, 1996), and even parents underestimate their daughters' talent and overestimate their sons' talent in male-typed activity (Eccles, 2009). Moreover, it is absolutely the case that all young people will see more examples of males engaged in these occupations than females (Eccles, 2007). In the long term, this has a strong impact on self-confidence, which is an essential element when individuals consider their expectations for success, give value to the options that they see as available in the field of technology, and finally when they make motivated behavioral choices.

It has been stated in several technology education curriculums that the technical development of society makes it necessary for all citizens to have a new readiness to use technical adaptations and to be able to exert an influence on the direction of technical development. Furthermore, students, regardless of their sex, must have the chance to acquaint themselves with technology and to learn to understand and use it. Nevertheless, technology education has often been blamed for not doing enough to resolve the problem of gender inequality in the field of technology. Based on this research, we have strong evidence for asking what the realistic possibilities are for resolving such a complex problem with just one school subject. The problem of inequality in the field of technology seems to be far more complicated than we previously thought. Action needs to be taken not just by technology education teachers but in cooperation with the whole society.

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